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Capabilities of Pressure Sensors in Tractor Hydraulic Systems

Capabilities of pressure sensors used in tractor hydraulic systems are the subject of this paper. Usually pressure signals provide information about enforced loads. The pressure sensor signal is not only useful for closed loop pressure control but also for a lot of other options. These options are analysed systematically, and illustrated through some practical examples. Particular advantages arise from an in-valve location of the pressure sensors within the three directional valves, because the signal processing can be executed directly with the valve's on board electronic (OBE).

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Keywords

Pressure sensors, directional valves, tractor hydraulic system

Directional control valves within the tractor hydraulics trigger power hitch and implement operation either in open or closed loop control systems. In many control and automation tasks the use of pressure signals is helpful. Accordingly the arrangement of pressure sensors near or within the hydraulic valve is reasonable. In this array a single sensor might be used for various devices and needs to be purchased only once.

By using pressure sensors, load pressure may be transcribed into equivalent quantities that can be processed. This enables extending the automated implement function and controlling the hydraulic function. Loading and unloading of freight (e. g. straw bails) is a case in point. Besides the automation of the loading and unloading process, the freight can be weighed and the total amount of goods may be summed up. Even position control may be achieved by the use of pressure sensors. Generally it can be stated that the application of pressure sensors broadens the tractor's capacity in accessing, controlling and automating the use of implements.

Characteristics in pressure signal history

The temporal course of one or more dependent pressure signals may be classified by various aspects. Consequently characteristic partitions (*Fig. 1*) can be extracted and assessed according to their features and type of utility, which can be used as indicators of a defined state or change of state (*Table 1 and 2*).

Apparently either a particular pressure level or a distinct change in pressure can be evaluated. Corresponding conclusions may be drawn from the remaining highlighted stream characteristics in Figure 1.

Examples of use

Electronically controlled kick out

Electronically controlled „kick out" may be conducted by various methods of analysis (*Fig. 2*). The electronic unit may control whether the working pressure (p_A) exceeds a predefined threshold (p_s) beneath the maximum system pressure or whether the working pressure gradient (dp_A/dt) surpasses a defined limit $(dp/dt)_s$. Additionally the difference in pressure between pump and consumer may be supervised. If the consumer is inactive, both pressures are equal. New assessment methods may be developed and derived from the combination of the three methods described above. For an instant and automatic switch off, delay might be created that can be used for the determination of time lapse (Δt) and prevents premature switch off in extremely varying flows.

Turning a plough with adjustable working width (Vario-plough)

Usually two cylinders are needed in the process of turning a Vario-plough: One cylinder pulls the frame upside down towards the upper dead centre and subsequently pushes it into its new working position. This application involves two electronically controlled kick out functions. One recognises the direc-

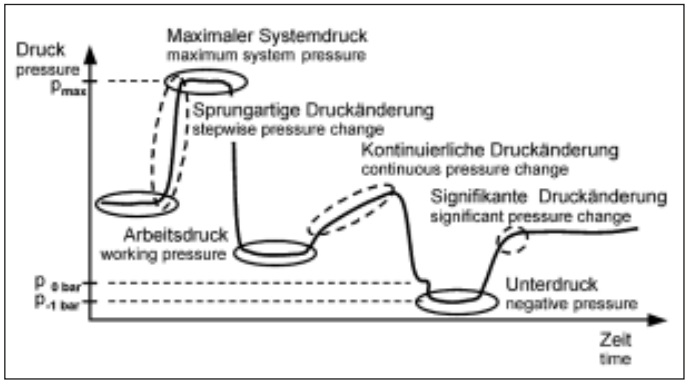
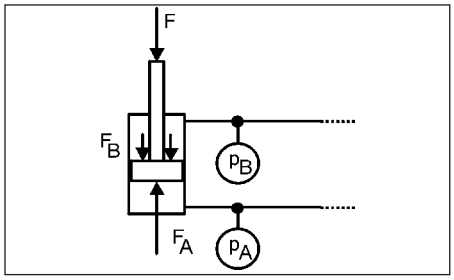
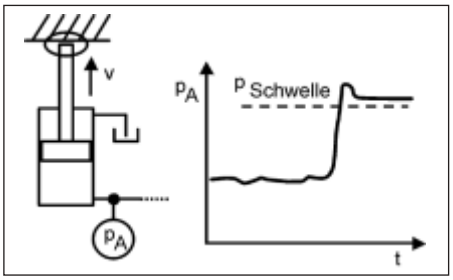
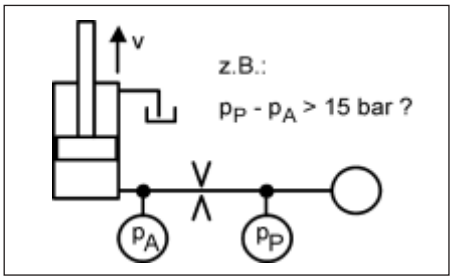


Fig. 1: Examplary course of pressure with characteristic sub ranges







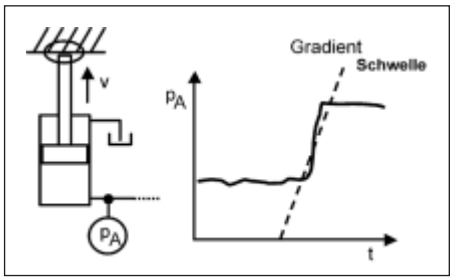
Working pressure
Signal generation
Pressure measurement on both sides of the valve
Evaluation
History of pressure, force, torque
Energy consumption of the actuator
Practical use
Cylinder force control, Torque control
in the hydraulic motor, Recording of load profiles
for service, Development of advanced maintenance
Service billing

Pressure threshold
Signal generation
Exceeding a predefined working pressure threshold

Evaluation
end point recognition (threshold set near maximum pressure), switching threshold recognition
Practical use
Condition for switching on / off in sequence control systems
Plausibility check in open loop control and in

Pressure difference
Signal generation
Difference in pump pressure and pressure within the active implement adapter
Evaluation
pump saturation, undersupply of individual consumers, end point recognition: Difference falls off volume flow measurement
Practical use
Avoiding undersupply
Basis for electrohydraulic load sensing

Table 1: Possibilities for analysing the course of pressure signal for a constant pressure level



Saltatory pressure change
Signal generation
Determination of working pressure gradient
Evaluation
Exceeding a predefined gradient threshold
Practical use
Recognition of end points, Characteristic intermediate positions and sharply rising pressure
Security tests by plausibility checks

Table 2: Valuation possibilities for pressure changes

tional change in the dead centre via the specific working pressure for each turn. And the second, which identifies the end position of the cylinder and accordingly the end of the turn. The second cylinder modifies the working width of the plough. Again an electronically regulated kick out is involved: It brings the plough into the minimal working width. After turning the plough any given final working width is adjusted via a time flow regulation system.

Weighing by using the tractor hitch
For weight assessment the absolute pressure within the hitch cylinder needs to be evaluated. Firstly the hitch is being lifted and lowered in order to adjust and balance the settings of friction and the centre of gravity. For any subsequent measure only slight movements of the hitch are required if the centre of gravity remains unchanged.

In addition to the given examples many more applications may be imagined. Best results may be achieved if all pressure signals are accessible for each control unit within or linked to the tractor. The commonly used LBS bus which is based on CAN or the newly developed ISOBUS systems are extremely useful for the above mentioned system array. Control systems need not necessarily to be developed by tractor or valve manufacturers but can be planned by implement manufacturers themselves. This ensures them independence in the development of their implements. To meet future needs Bosch Rexroth has designed directional valves including integrated pressure sensors that can be addressed via the CAN-Bus system.

Future prospects

Valve-integrated pressure sensors deliver signals of complex information, which can be analysed in various ways. These allow new capacities for surveillance, control and automation of hydraulic processes to be developed. Future applications are of a great variety and require thorough development. Proper system array is crucial as only this guarantees the independence of manufacturers producing tractors, hydraulic devices and implements, respectively. Hence the pressure signal being generated on the tractor needs to be equally accessible by all subsystems.

Future tractor valves by Bosch Rexroth will allow all the mentioned and imaginable applications.

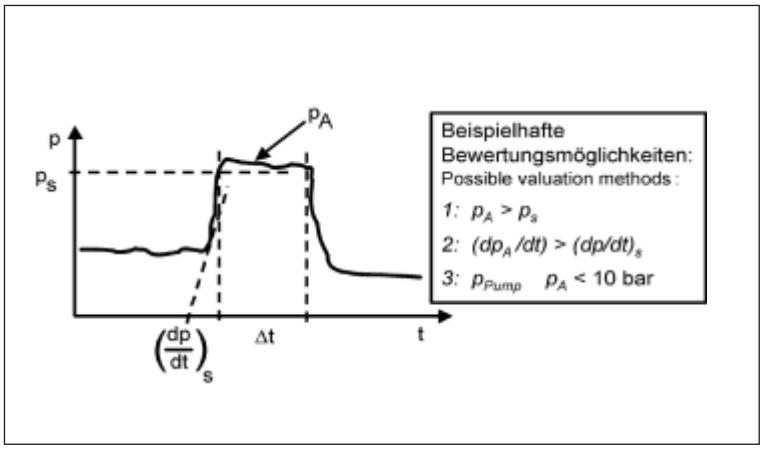


Fig. 2: Electronically controlled Kick Out with different valuation methods